Restored corridors as potential habitat for resident bird species in the Central Andes of Colombia

Corredores restaurados como hábitat potencial para especies de aves residentes en la Cordillera Central de Colombia

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Abstract

The restoration of habitat corridors and the conservation of remnant forest strips or riparian habitats have been proposed as tools to enhance connectivity in fragmented landscapes. To determine corridor effectiveness some studies have evaluated species presence and movements, but life cycle activities are rarely used as measurements of success. In this study we gathered molt and breeding evidences for 20 individuals of 15 bird species in three corridors that were actively restored between 2003 and 2006 to reconnect two Andean forest fragments. Overall, 25% of the captured individuals displayed overlap between molt and breeding. Our findings indicate that restored corridors that improve connectivity in fragmented landscapes are highly important, not only for the movement of individuals but also as habitat to perform important life cycle activities, like molt and breeding. We propose that recording those life cycle activities for bird species is a reliable indicator to determine whether restoration efforts have been successful.

Key words: connectivity, fragmentation, habitat, life cycle, molt, reproduction

Resumen

La restauración de corredores de vegetación nativa y la conservación de corredores de hábitat o de bosques riparios han sido propuestas como herramientas para aumentar o restituir la conectividad en paisajes fragmentados. Algunos estudios han evaluado la presencia o el movimiento de las especies para determinar la eficacia de los corredores, pero los eventos del ciclo de vida han sido pocas veces tomados como indicadores de éxito. En este estudio recopilamos evidencias de muda y reproducción para 20 individuos de 15 especies en tres corredores que fueron restaurados entre el 2003 y el 2006, los cuales reconectaron dos fragmentos de bosque andino. En total, el 25% de los individuos mostraron evidencia de muda y reproducción simultáneas. Nuestros resultados estarían indicando que los corredores que aumentan la conectividad en paisajes fragmentados son altamente importantes, no sólo para el movimiento de los individuos, sino también como hábitat para llevar a cabo importantes actividades del ciclo de vida. Proponemos que las evidencias de muda y reproducción se pueden tomar como indicadores del éxito de estrategias de restauración.

Palabras clave: conectividad, ciclo de vida, fragmentación, hábitat, muda, reproducción

Introduction

Corridors are defined as strips of habitat that are embedded in a different matrix and connect isolated habitat fragments (Beier & Noss 1998). The connectivity of habitats through corridors may be viewed as structural or functional (*Kool et. al.* 2013). Structural interpretations of connectivity focus on landscape characteristics (including the matrix) such as composition, configuration and matrix permeability (Dunning *et al.* 1992, Taylor *et al.* 1993). In contrast, functional connectivity is strongly related to the life history of species (Kool *et al.* 2013), and corresponds to the actual capacity of a species to use the landscape as a function of the suitable habitat that such landscape provides (Uezu *et al.* 2005, Kupfer *et al.* 2006). In the short term, species persistence in isolated habitat patches might be possible even when resources are scarce and (functional) connectivity is low (Hilty *et al.* 2006). Nevertheless, successful dispersal and recolonization are key requisites for the long-term survival of species in fragmented landscapes, and corridors may facilitate these important life history events (Wiens 1997).

Corridors allow movement of individuals among different habitat types that can be used for dispersal, breeding, feeding, molting, or roosting (Soulé 1991). Line corridors can be fencerows and hedgerows and contain only edge habitat; these connect close and small habitat patches and are appropriate for the movement of small vertebrates (*i.e.,* mice, chipmunks, or passerine birds: Noss 1991). Strip corridors are wider and longer and connect larger patches, creating a landscape mosaic; they include various habitat types like riparian forests and some interior habitat (Noss 1991). Forested streams can also act as efficient corridors for plant species in fragmented landscapes (Araujo Calçada *et al.* 2013). Wider corridors that connect nature reserves in regional networks are useful to link populations of big mammals (Meffe & Carroll 1997), such as lynx (Jędrzejewski *et al.* 2002) or wolves (Jędrzejewski *et al.* 2001). The effectiveness of either class of corridor is related to the scale at which species perceive the landscape and perform life history traits such as dispersal and reproduction (Clergeau & Burel 1997).

Landscape structure and organism movement (*i.e.,* use of corridors) are interdependent and this relation is usually known as connectivity, an important landscape property (Merriam 1984). The capacity of connectivity to influence animal populations in heterogeneous landscapes and the important implications for conservation biology has increased interest in the study of landscape connectivity (Goodwin 2003). Because of their importance for connectivity, assessing the quality of corridors and how they are used by wildlife is crucial for conservation programs. Different authors have evaluated the effectiveness of biological corridors, asking whether they promote movement and connect populations effectively (Beier & Noss 1998, Gilbert-Norton *et al.* 2010), or if they enhance the presence of focal species, movement between patches, gene flow, and patch occupancy (Gregory & Bier 2014). Other studies have analyzed bird movement patterns in landscapes containing natural corridors (Castellón & Sieving, 2006), live fences, and isolated trees (Graham 2001, Pulido-Santacruz & Renjifo 2010). Finally, other researchers have assessed habitat use, breeding success (Sekercioglu *et al.* 2007), and nest predation in agricultural landscapes (Willson *et al.* 2000). Nevertheless, to our knowledge there are no studies focused on documenting specific life cycle events such as reproduction or molt of bird populations within restored corridors.

Molt, as a key event in the life cycle, is defined as the regular replacement of feathers and integument (Palmer 1972). Birds need to replace their feathers because they are constantly worn out during flight, by the action of ectoparasites, UV radiation, and the contact with hard surfaces (Fox *et al.* 2008, Rohwer 2008, Muijres *et al.* 2012). Breeding is another major life cycle event and typically precedes molting (Gill 2007, Echeverry-Galvis & Córdoba 2008). Not without debate, it has been suggested that food abundance acts as a regulator for the occurrence of breeding (Snow & Snow 1964, Poulin 1992). Given that reproduction and molt are energetically demanding (Snow & Snow 1964, Pyle 1997), these events must be scheduled when the bird's requirements for self-maintenance are lowest or when food availability is greatest (Gill 2007) and that is why they typically occur at different times during the year. However, some birds include an overlap between molt and breeding, including temperate species (Hemborg 1999) and tropical resident birds (Snow & Snow 1964, Foster 1975, Echeverry-Galvis 2001, Johnson *et al.* 2012, Echeverry-Galvis & Hau 2013).

In this study, we present molt and reproductive evidence for resident Andean bird species, which were captured or observed in three restored corridors that structurally connect two large forest fragments in the Central Andes of Colombia. Our findings constitute the first evidence of those life cycle activities in this type of corridors and this possibly suggests that birds are using these restored corridors as habitat and not only for sporadic movement.

Methods

Study site.- The study area is located in the Central Andes of Colombia, in the departments of Quindío and Risaralda (Fig. 1A). The region is classified as sub-Andean forest (Cuatrecasas 1958) or subtropical wet forest (Holdridge 1967). Rainfall regime is bimodal with peaks of precipitation in April-May and October-November. There are two dry seasons, a mild one occurs in December-January and a more pronounced one in July-August (Aguilar & Rangel 1994). Temperature fluctuates between 18 and 24°C, and annual precipitation oscillates between 2,000 and 4,000 mm/yr (IGAC 1988). Pastures for cattle and exotic-tree plantations (*Pinus, Cupressus* and *Eucalyptus*) dominate the landscape (Renjifo 1999). Such matrices surround some native forest remnants, including two large tracts: Barbas (731 ha) and Bremen (840 ha) (Fig. 1B). By the beginning of the 18th Century this area was covered by continuous forest; deforestation began in the mid-19th Century with the settlement of the first towns, but the dominant matrix was still extensive forest when the first ornithologists studied the area in the early 20th Century (Renjifo 1999). Later, from 1970–1991 some of the cattle pastures were replaced by exotic-tree plantations (D. Martínez pers. com. in Marín-Gómez *et. al.* 2009). Between 2003 and 2006 a total of four forest corridors (Colibríes, Pavas, Laureles, and Monos, Fig. 1B) were restored, which reconnected the main forest tracts of Bremen and the Barbas river canyon. Our observations and captures took place inside all corridors except Laureles, because it is located in a private property to which we could not get access.

These corridors were established on either grazing pasture or recently clear-cut exotic-tree plantations, and were restored by accelerating the process of natural succession, a technique that consists in planting species of intermediate and advanced successional stages during the initial establishment stage (Palmer *et al.* 1997). In the case of the Barbas-Bremen corridors, the final objective was to restore an advanced secondary native forest, instead of a mature forest (Vargas 2008). In three years the trees reached a canopy >12 meters and the corridors had a similar structure and composition as secondary forests, including threatened tree species (Cavelier *et al.* 2008).

Evaluating breeding, molt, and their overlap.- Inside the corridors, we operated five to seven 12 x 2.6 m, 30 mm mesh mist nets, placed in arrangements of two or three nets, perpendicular to the direction of the corridors, at ground level. This was done from 06:00 to 11:00 and from 14:00 to 16:00, on 1 to 14 May (686 net-hours), 13 to 19 June (245 net-hours) and 17 to 27 July

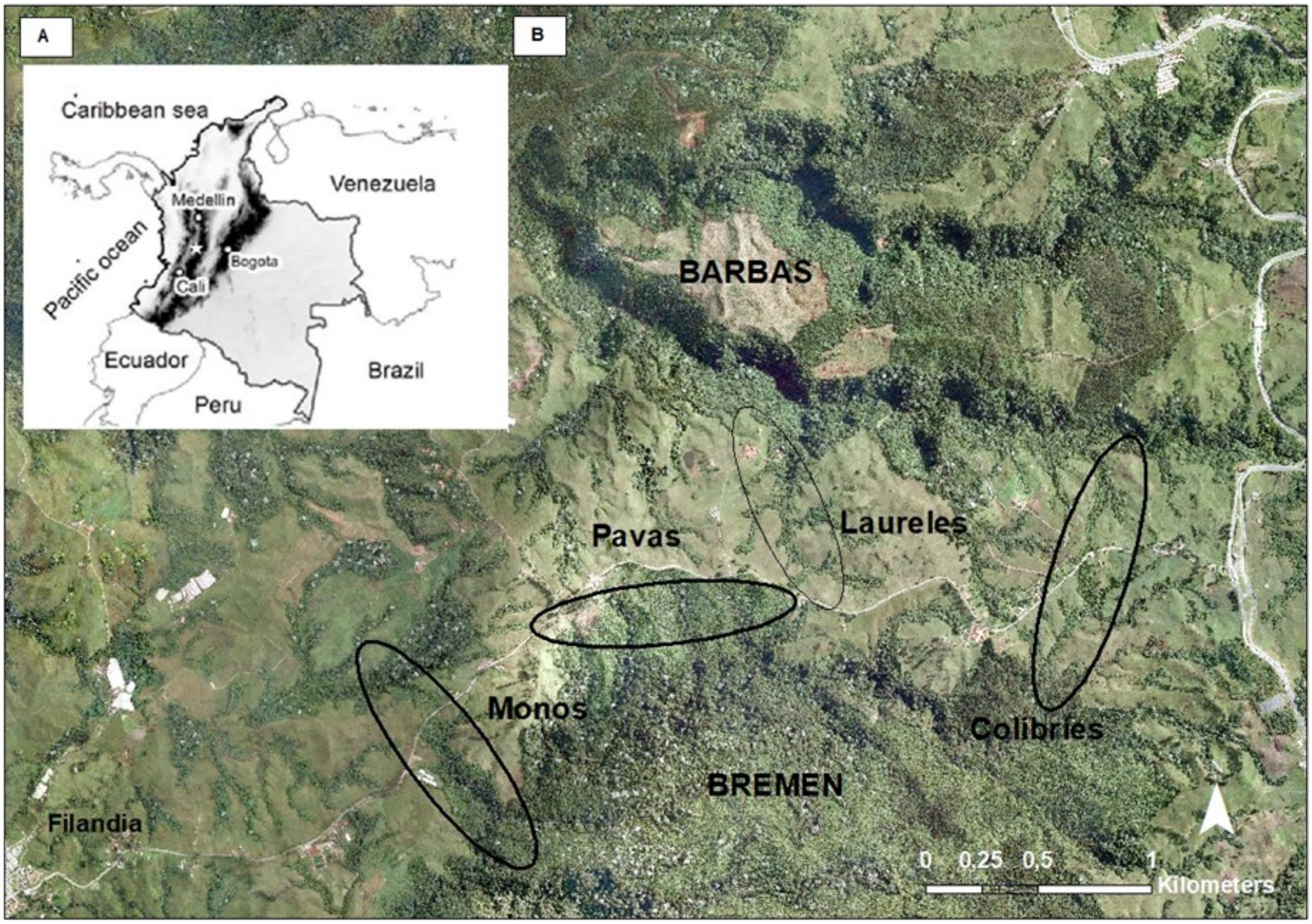

Figure 1. **(A)** Location of the study area in the western slope of the Cordillera Central of the Colombian Andes. **(B)** Landscape view showing the main forest tracts: Bremen and Barbas River Canyon and the restored corridors: Colibries, Pavas, Monos and Laureles, which was not sampled and is indicated with a narrower line. The nearest town, Filandia, is shown on the left bottom corner.

(539 net-hours) of 2013, for a total of 1470 net-hours.

Following Johnson *et al.* (2012), for every individual captured we defined molt as symmetrical replacement of wing and tail feathers, given that molt of flight feathers are reliable indicators of true molting events, contrary to adventitious or accidental replacement of feathers which may occur year-round (Howell *et al.* 2003). Breeding status was defined as the presence or absence of a brood patch, indicated by a belly region without feathers, wrinkled and with hyper-vascularization corresponding to the categories 3 and 4, following Redfern & Clarck (2001). We did not consider the presence of cloacal protuberances as a trustful indicator of reproductive status (J. Wolfe pers. comm). We considered molt-breeding overlap to happen when birds were molting primary feathers and simultaneously had a developed brood patch. Also, we carried out *ad libitum* observations around the three corridors, in order to record signs of reproductive activity, such as open cups or cavity nests, adults making visits to nest and feeding fledglings.

Results

Overall, 40 individuals of 24 species were captured or observed, which corresponds to 26% of the bird species previously reported using the corridors (Marín-Gomez *et al.* 2009). Of these, 20 individuals of 15 species were recorded breeding, molting, or both (Appendix 1) and correspond to 13 individuals (32.5%) that showed signs of breeding, 11 individuals (27.5%) that were molting and seven individuals (17.5%) that were overlapping molt and breeding.

We observed six individuals of five different species performing reproductive events during the *ad libitum* observations: three individuals of two cavity nesting species (male and female of *Trogon collaris,* and one male individual of *Eubucco bourcierii*) were found nesting inside the Monos corridor. Also, a cup nest of *Atlapetes albinucha* was found in the Pavas corridor and cup nests of, *Turdus leucops*, and *T. fuscater* were found inside the Colibries corridors. A fledgling of *Myadestes ralloides* was photographed in the Pavas corridor (Fig. 2).

We gathered reproductive evidence for 15 individuals of 10 species and inform about reproductive times previously reported by other authors in other localities in Colombia and other Andean countries (Table 1).

Discussion

To our knowledge, our findings constitute the first evidence that energetically costly life cycle activities (*i.e.,* molt, breeding and overlap) are performed by birds in restored corridors. Nevertheless, studies at the community level are extremely important, since the incidence of molt and breeding evidences may indicate general patterns of the annual cycle of birds at the local level and this may help elucidate how they are related to the local environmental characteristics (Marini & Durães 2001). For tropical regions, environmental factors that trigger the reproductive season include rain regimes and the offer of food resources (Lack 1968); meanwhile, molt usually starts after reproduction is completed (Gill 2007). Still, molt and breeding can overlap and this can be explained in two different ways. One, that food is a limiting resource so the overlap occurs when there is a short and abundant explosion of it (Hemborg & Lundberg 1998). Two, food resources are constant and abundant through time, so that overlapping both events maximizes the reproductive period at expenses of feather growth rate (Foster 1974). The molt-breeding overlap evidences found in our study could be taken as indicators of the state of the habitat that these restored corridors provide, however, more studies are needed in order to understand the factors that trigger these life cycle events in this particular bird community. It would be interesting to understand if the phenology of the restored plant community follows the same fruiting periods as the bigger forest fragments. Also, during our field season we found some portions of the corridors invaded by non-native grass species, like *Axonopus* sp., evidencing the importance of gathering information regarding invasive and exotic species effect on habitat availability. Our findings are of great importance, since they suggest that birds are using the restored corridors as habitat and not only for sporadic movement.

Despite the high energetic cost that an overlap between molt and breeding might impose, Foster (1974) stated that the proportion of overlap is higher in tropical than in temperate habitats, due to a prolonged breeding period in the tropics. Protracted breeding seasons are related to a higher immune response in tropical birds, due to a higher incidence of parasites (Moreno 2004). In a study completed at a tropical cloud mountain forest of the Colombian Andes, Echeverry-Galvis (2001) found that 28% of the individuals showed an overlap between these two activities. In our study, we found that 17.5% of the individuals showed an overlap between molt and

Figure 2. Photographic records of some species nesting inside the corridors that connect the forests of Barbas and Bremen in the central Andes of Colombia: **(A)** Adult male of *Eubucco bourcierii* **(B)** Nestlings of *Turdus leucops* **(C)** Fledgling of *Myadestes ralloides* **(D)** Nestlings of *Atlapetes albinucha* **(E)** Eggs of *Trogon collaris*.

reproduction. In contrast, in the lowlands of the Central Amazonia in Brazil, Johnson *et al.* (2012) found overlap in 12% of the individuals. In the lowlands of Costa Rica, the 9% of the individuals showed evidence of molt-breeding overlap (Foster 1975). Piratelli *et al.* (2000) registered a 3.2% overlap in the lowlands of southwestern Brazil and Marini & Durães (2001) reported a 2% overlap in a study completed at locations at 1,000 m in central Brazil. This could suggest that overlapping molt and reproduction is a more common event at the community level in the tropical highlands than in the lowlands, but more studies are needed in order to establish a pattern.

We spent over one month in the field during the wet season (May), the transition from rainy to dry season (June), and the beginning of the driest season of the year (July). Our data indicate that these months constitute an important breeding season for birds at this locality in the Central Andes of Colombia, but sampling along a whole year is needed to identify other important breeding periods. When we compared our findings with available literature for reproductive reports, we found that the 11 species breeding inside the corridors were coincident in time with what other authors had reported in other localities across the Colombian Andes, as well as in other meotropical areas.

For *M. aequatorialis* reproductive activity was recorded on July, which had not been reported in Colombia, but matches the reproductive period in Ecuador, which goes from January to May and from July to November (Greeney *et al.* 2006). Until 2009, this species was previously classified as a subspecies of (*M. momota*), but was later elevated to the species level by Stiles (2009). For *T. fuscater* reproduction has been reported through most of the year in other locations in Colombia (January-September), similar to what Greeney & Nunnery (2006) found for various

Table 1. Reproductive times and evidences found for 15 individuals of 10 species and reproductive times previously reported by other authors in other localities in Colombia and other Andean countries.

Species	Reproductive time in this study	Reproductive times previously reported	Locality and authors
Trogon collaris	On June 19th a nest containing two white eggs was found in the "Monos" corridor, located inside a cavity carved into half-rotten tree trunk, 1 m from the ground. We observed the male and female perching in close branches.	Between April–August 12 individuals in breeding condition were found in the Sierra Nevada de Santa Marta, Perijá Mountains and West and Central Andes in Colombia. A cavity nest with 2 white eggs inside was found on March 5th in the National Park Cueva de los Guácharos.	Sierra Nevada de Santa Marta, Perijá Mountains and West and Central Andes in Colombia (Carriker in Hilty and Brown 1986). National Park Cueva de los Guácharos (Gertler in Hilty and Brown 1986).
Momotus aequatorialis	On July 20th a female was captured with a possible egg in the abdomen.	In east Ecuador active nests were discovered between January–May and July-November. Gonadal condition of specimens indicated probable lying in the second half of March and in September. In Colombia, two females in breeding condition were found in January and June in the Central and Western Andes. A breeding individual was found in February in the Macarena Mountains.	East Ecuador (Greeney *et. al.* 2006). Central and Western Andes (Carriker in Hilty and Brown 1986). Macarena Mountains, Colombia (Olivares 1962).
Eubucco bourcierii	On May 7th one individual was observed inside a cavity nest, carved into a *Cecropia* spp. tree, in the "Monos" corridor.	Two cavity nests were found in Panama in June-July. Breeding individuals were found in March–July from Central America to Colombia, Ecuador and Peru. Also in December–April in Venezuela. Five individuals in breeding condition were found in March-June in West and Central Andes of Colombia.	Panama (Worth 1983). From Central America to Colombia, Ecuador and Peru. Venezuela (del Hoyo et al. 2013). West and Central Andes (Miller 1963).
Aulacorhynchus haematopygus	On May 14th one individual was captured in the "Monos" corridor, showing a brooding patch.	Young fledged between February-March in South West Ecuador –March. Breeding time occurs in January–May, and as early as November in Ecuador and South Colombia. Three birds in breeding condition were found in March-May in the Central Andes of Colombia. Two individuals in breeding condition were caught in April in the West Andes in Valle del Cauca, Colombia.	South West Ecuador (Best et al. 1996). Central Andes of Colombia (Carriker in Hilty and Brown 1986). West Andes in Colombia (Miller 1963).
Pyroderus scutatus	On 27th July a female individual was captured in the "Colibries" corridor, carrying an egg in its abdomen. We also observed a male that accompanied the female several days before and after the capture. After the female was caught, both individuals were seen in the corridor for two days but then moved to a ravine, where they were difficult to follow due to the steepness of the terrain.	In the Central Andes of Colombia egg lying occurs in March–July, with a peak in April–May. Four individuals in breeding condition were found in April–May in the Perijá Mountains, Colombia.	Central Andes of Colombia (del Hoyo *et al.* 2013). Perijá Mountains, Colombia (Carriker in Hilty and Brown 1986).
Cyanocorax yncas	Two individuals were captured: one in May 14th at "Monos" corridor and another in July 21st at "Colibries" corridor, both showing brooding patches.	Eggs recorded in March–August in the Andes of Colombia. In Antioquia, Colombia breeding was reported to start in March and by mid-May fledglings were observed. Five individuals in breeding condition were found in April-August in the Western Andes and the Perijá Mountains.	Andes of Colombia (del Hoyo et al. 2013). Colombian Central Andes (Antioquia) (Álvarez-López 1976). Western Andes and the Perijá Mountains (Carriker in Hilty and Brown 1986).

Table 1 (cont.). Reproductive times and evidences found for 15 individuals of 10 species and reproductive times previously reported by other authors in other localities in Colombia and other Andean countries.

Species	Reproductive time in this study	Reproductive times previously reported	Locality and authors
Turdus fuscater	On May 1st at "Colibries" corridor a female was captured showing brooding patch and a nest with two eggs was found on May 12th, on top of an arboreal fern, where two blue and brown spotted eggs where found.	Breeding occurs in March–April in Venezuela, October in Ecuador and February and June in Peru. Seven birds in breeding condition were recorded in January–August in Perijá Mountains. Two fledglings reported in January in Boyacá, Colombia and parents were found carrying food in September in Bogotá, Colombia.	Venezuela, Ecuador and Peru (del Hoyo *et al.* 2013). Perijá Mountains (Carriker in Hilty and Brown 1986). Boyacá, Colombia (Borrero 1955).
Turdus leucops	On 19 July we captured a male in the "Colibries" corridor. Later we found a nest with two nestlings on a small cliff made of mud and grass, approximately 1.20 meters above the ground. For several days we observed the male and female visiting the nest.	Reproductive season in Ecuador goes from December to June. Adults carrying food and recently fledged young reported in Anchicayá Valley, Colombia in June. One male in breeding condition reported in Huila in May. Two nests were found on a nearby location in the Central Andes on April and May 2003.	Ecuador (Halupka and Greeney 2009). Anchicayá Valley, Colombia (del Hoyo *et al.* 2013). Huila, Colombia (Carriker in Hilty and Brown 1986). Central Andes (Londoño 2005).
Atlapetes albinucha	On May 6th we found a nest with two nestlings inside the "Pavas" corridor. It was a shallow cup, at approximately 0.40 m above the ground, built between the foliage of the invasive grass (*Axonopus* sp.). We monitored the nest and nestlings for 10 days and in May 16 th the nestlings left the nest.	In Colombia, seven birds in breeding condition recorded on May–June in West and Central Andes. Two male individuals in March-April plus begging juvenile in March and September, reported on the same locality. Begging young recorded in June and August also at West Andes of Colombia. Nest found In the West Andes one in March.	West and Central Andes (Carriker in Hilty and Brown 1986). West Andes of Colombia (Miller 1963). West Andes of Colombia (Gniadek in Hilty and Brown 1986). West Andes of Colombia (Hilty and Brown 1986).
Euphonia xanthogaster	In July 27th one male with brooding patch was captured.	Adult seen cleaning nest in November in Peru. Fledglings found in mid-February to early March in South West Ecuador. May–July. In Colombia, eight birds in breeding condition recorded in May–July in Perijá Mountains and Central Andes in Antioquia and Caldas. One breeding individual in March in Chocó. Five individuals in breeding condition found in February-April in W. Andes. Seven nests found in November–April in West Andes, Valle del Cauca.	Pasco, Peru (Janni *et. al.* 2008). South West Ecuador (Best *et. al.* 1996). Perijá Mountains and Central Andes in Antioquia and Caldas, Colombia (Carriker in Hilty and Brown 1986). Chocó, Colombia (Haffer 1975). West Colombian Andes (Miller 1963). West Andes, Valle del Cauca, Colombia (Hilty and Brown 1986).

species in northwest Ecuador; therefore, reinforcing the importance of monitoring throughout the entire year to determine species-specific seasonality.

Following the classification by Renjifo (2001), based on the species´ habitat association, we can infer that most of the species found here molting, breeding or overlapping both, are associated with forested habitats, except *Leptotila verreauxi* and *A. albinucha* which are considered edge species, and *T. ignobilis* that is categorized as a non-forest species. Renjifo (1999) also classified the avifauna of the region in four categories, according to their response to fragmentation. We documented two species that decline in abundance with forest fragmentation, regardless of the anthropogenic matrix (*T. leucops* and *Anisognathus somptuosus*). Also, we documented four species in our study that decline in abundance with fragmentation, but can be buffered by an exotic-tree plantation matrix: *T. collaris, P. scutatus, C. yncas* and *M. ralloides*. Likewise, we found four species that increase in abundance in forest remnants with the replacement of the continuous forest matrix by anthropogenic matrices: *M. aequatorialis, Aulacorhynchus haematopygus, L. verreauxi* and *T. ignobilis*. Finally, we documented four species that show no significant differences in relative abundance in forests surrounded by the three matrix types: *E. bourcierii, T. fuscater, A. albinucha* and *Euphonia xanthogaster.*

According to these classifications, the species found molting and breeding in the restored corridors are mostly associated to forest habitat, and some other species occupy edge and open areas. Pulido-Santacruz & Renjifo (2010) found breeding evidence for birds associated with forest, edge and non-forest, and that were using live fences in another locality in the Colombian Central Andes.

To our knowledge, no other studies have evaluated reproduction in corridors in the Andes of Colombia. Our records indicate that forest bird species, both habitat specialists and generalists, can find appropriate habitat to accomplish important life cycle activities (molt and reproduction) in the restored corridors that connect the Barbas and Bremen forest fragments. This evidence constitutes the first of such records gathered in any restored corridor in Colombia. Nest success and survival of birds decline in fragmented landscapes (Newmark & Stanley 2011), but several authors have found that birds use corridors to move and nest in connected forest patches (Haas 1995, Machtans *et al.* 1996, Gilles & St. Clair 2008). For this reason, habitat corridors for forest birds should contain interior habitat because more edge habitat might contain more predators and nest parasites (Meffe & Carroll 1997, Marzluff & Ewing 2001). Further studies should address questions related to habitat use, breeding success, dispersal ability, and nest predation to evaluate if corridors are acting as links in a meta-population dynamics or if they might be acting as ecological traps for bird species. Consequently, recording life cycle activities could be an indicator to determine whether restoration efforts are being successful. Our findings indicate restored corridors that improve connectivity in fragmented landscapes are highly important, not only for the movement of individuals, but also as habitat to perform important life cycle activities.

Acknowledgments

The authors would like to thank all the people who provided lodging, help with logistics and assistance as well as training in the field. Also, we would like to acknowledge the Cleveland Metroparks Zoo for awarding the Scott Neotropical Fund, the Facultad de Estudios Ambientales y Rurales at Pontificia Universidad Javeriana (Bogotá) and IdeaWild for funding. We would also, like to thank the Municipalidad de Filandia (Quindío), the Corporación Autónoma del Quindío (CRQ), and the UMATA for granting the research permits. Finally, we would like to thank Gustavo Kattan and two anonymous reviewers for improving the initial versions of this manuscript.

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Recibido: 25 de abril de 2017 *Aceptado:* 12 de diciembre de 2017

Editor asociado
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Citación: MONTEALEGRE-TALERO. C., M. A. ECHEVERRY-GALVIS. & L. M. RENJIFO. 2017. Restored corridors as potencial habitat for resident bird species in the Central Andes of Colombia. Ornitología Colombiana 16:eA07.

Appendix. Individuals captured with signs of breeding, molt or overlap of both, captured in the Colibríes, Pavas and Monos corridors in May, June and July 2013

Family[1]	Species[1]	Sex	Molt*	Nesting**	Brood patch	Response category to fragmentation ***	Dates	Recorded in corridor	Type of record
Columbidae	*Leptotila verreauxi*	U	Yes	U	No	3	4/5/2013	Monos	Captured
	Leptotila verreauxi	U	Yes	U	No	3	21/7/2013	Colibries	Captured
Trogonidae	*Trogon collaris*	F	U	Yes[2]	U	2	19/6/2013	Monos	Photographed
	Trogon collaris	M	U	Yes[2]	U	2	19/6/2013	Monos	Photographed
Momotidae	*Momotus aequatorialis*	U	Yes	U	No	3	17/7/2013	Colibries	Captured
	Momotus aequatorialis	F	No	U[3]	No	3	20/7/2013	Colibries	Captured
Capitonidae	*Eubucco bourcierii*	U	U	Yes[2]	U	4	7/5/2013	Monos	Photographed
Ramphastidae	*Aulacorhynchus haematopygus*[2]	U	Yes	U	Yes	3	14/5/2013	Monos	Captured
Furnaridae	*Thripadectes virgaticeps*	U	Yes	U	No	Not classified	24/7/2013	Colibries	Captured
Contingidae	*Pyroderus scutatus*	F	Yes	U[3]	No	2	27/7/2013	Colibries	Captured
Corvidae	*Cyanocorax yncas*	U	No	U	Yes	2	21/7/2013	Colibries	Captured
	Cyanocorax yncas	U	No	U	Yes	2	14/5/2013	Monos	Captured
Turdidae	*Turdus fuscater*	F	No	Yes	Yes	4	1/5/2013	Colibries	Captured
	Turdus ignobilis	U	Yes	U	No	3	24/7/2013	Colibries	Captured
	Turdus leucops	M	No	Yes[4]	No	1	19/7/2013	Colibries	Captured
	Myadestes ralloides	U	U	Fledgling	U	2	18/6/2013	Pavas	Photographed
Thraupidae	*Anisognathus somptuosus*	U	Yes	U	No	1	24/7/2013	Colibries	Captured
Emberizidae	*Atlapetes albinucha*[4]	U	No	Yes[5]	No	4	6/5/2013	Pavas	Photographed
	Atlapetes albinucha[4]	U	No	Yes[5]	No	4	6/5/2013	Pavas	Photographed
Fringillidae	*Euphonia xanthogaster*	M	Yes	U	No	4	27/7/2013	Colibries	Captured

[1] Taxonomy follows Remsen *et al.* 2017

[2] Individual nesting inside cavity on dead tree

[3] Female with egg in cloacae

[4] Open nest found and adult(s) observed making trips to feed nestlings

[5] Nestlings found in open nest; parents observed flying around nest

* Molt status was defined as the presence or absence of primary feather molt

** Evidence of open-cup nest or cavity nest occupied by the individuals.

*** Response categories to fragmentation, *sensu* Renjifo (2001): Response category 1: species decline in abundance with forest fragmentation, regardless of the anthropogenic matrix. Response category 2: species decline in abundance with fragmentation, but the decline is buffered by the exotic-tree plantation matrix. Response category 3: species increase in abundance in forest remnants with the replacement of the continuous forest matrix by anthropogenic matrices. Response category 4: species show no significant differences in relative abundance in forests surrounded by the three matrix types.

U: unknown F: female M: male